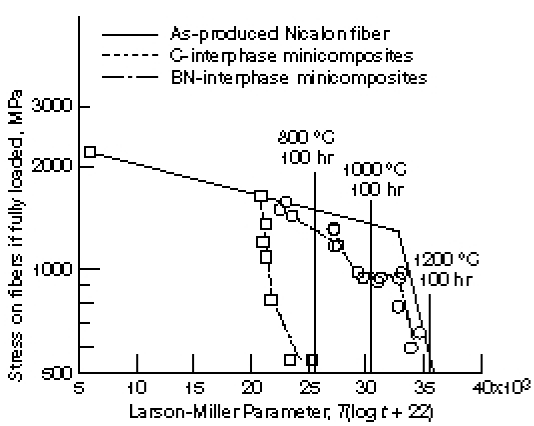
Single-Tow Minicomposite Test Used to Determine the Stressed-Oxidation Durability of SiC/SiC Composites

SiC-fiber-reinforced SiC-matrix composites are considered future materials for high-temperature (>1200 °C), air-breathing applications. For these materials to be successful, they must be able to maintain desirable mechanical properties at high temperatures while existing in highly corrosive environments. The critical constituent of a ceramic matrix composite is a thin interphase layer between the fiber and matrix which enables matrix cracks to deflect around the fibers, that is, to perform even when damaged. Unfortunately, the only interphase materials (to date) that offer the desired properties are carbon and boron nitride. Both of these materials react with oxidizing environments to form gaseous or liquid oxidation products that can lead to fiber-strength degradation or strong bonding between the fiber and the matrix at temperatures above ~600 °C.

Because it is important to understand the failure mechanisms and lifetimes expected for these composites under stressed-oxidative conditions, a single-tow minicomposite test was developed at the NASA Lewis Research Center to evaluate a number of different fiber/interphase combinations to determine which system has the best properties. The minicomposite consists of a single tow of SiC fibers (there are ~500 15-µm-diameter fibers in a tow), an interphase material (0.5-µm-thick C or BN), and a chemical-vapor-infiltrated SiC matrix.

A stress-rupture test was used to determine the stressed oxidative behavior of the minicomposite systems. Minicomposites were first precracked with a relatively high load to expose the interphases to the environment. Then, they were placed in a stress-rupture rig where a constant load and temperature (700 to 1200 °C) were applied until the minicomposite failed.



Rupture properties for C-interphase and BN-interphase minicomposites in air. Temperature in degrees kelvin, T; time in hours, t.

We found that the carbon-interphase minicomposites had significantly poorer rupture

properties than the BN-interphase minicomposites. These data were compared with what would be expected for individual fiber-rupture data with the same starting fiber strength (this is considered to be the best any composite could do with these fibers). Drastic degradation in rupture properties occurred at ~700 °C for carbon-interphase minicomposites. Microscopy showed that the carbon-interphase disappeared and the Nicalon fiber degraded to cause this behavior. For the BN-interphase minicomposites, only mild degradation in rupture properties occurred. In fact, the degradation in rupture properties for the BN-interphase minicomposites is about the same as that for the individual fibers, except for the data at ~950 ± 100 °C. Microscopy showed that the BN-interphase also disappeared; however, glass layers were formed on the fiber surface and fiber/matrix bonding occurred for ≥900 °C experiments. It is presumed that this intermediate temperature composite "embrittlement" was due to increased stress concentrations on the fibers as a result of the strong bonding. At 1200 °C, glass filled the interphase region; however, the minicomposite rupture properties were the same as the fiber-rupture properties. It is evident that BN-interphase SiC/SiC composites are superior at high temperatures. This study is being advanced to understand cyclic loading conditions where the susceptibility to stress-concentrations are greater.

Lewis contact: Gregory N. Morscher, (216) 433-5512,
Gregory.N.Morscher@grc.nasa.gov
Author: Gregory N. Morscher
Headquarters program office: OA